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CONTINUATION-IN-PART APPLICATION

LIVESTOCK COOLING SYSTEM

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Title: Livestock Cooling System

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Cross-Reference to Related Application: This is a continuation-in-part of U.S. Application Serial Number 10/435,469 filed on May 9, 2003, for which the inventors claim domestic priority. Serial Number 10/435,469 is a continuation application which claims priority to U.S. Application Serial Number 09/967,678 filed on September 28, 2001, which has issued as U.S. Patent No. 6,578,828.

BACKGROUND OF THE INVENTION

The present invention generally relates to devices and systems for sheltering livestock, including horses, cattle, swine and poultry, and more specifically to a programmable system for efficiently using evaporative cooling devices to create an environment which protects the health and productivity of the animals.

It is known in animal agriculture to cool livestock with evaporative cooling by wetting the animal and then drying the animal through mechanical ventilation or via natural ventilation. Alternatively, lowering the temperature of the environment will also cool animals if the decreased temperature may be maintained. The disclosed system provides cooling to livestock through direct evaporative cooling and also by decreasing the temperature of the livestock environment.

The disclosed system may deliver small water particles or fog to a desired area without wetting the area, unlike the other known devices which wet one area continuously and usually result in wet bedding. With the disclosed system, as a fan oscillates over a range of positions, by the time the fan returns to a starting position, water particles previously emitted have partially or totally evaporated. Temperature and humidity may be monitored so that the maximum amount of water for evaporative cooling can be supplied to each fan under real time environmental conditions. The upper constraint on the amount of water delivered by each fan will usually be a

volume of water which would wet the animal's bedding. Other environmental conditions may also be monitored, such as wind velocity, the intensity of sunlight, or the position of the sun with respect to the location of the livestock and a shading structure.

The disclosed system can be configured to emit water at high pressure through small diameter nozzles, resulting in a small water particle fog, such that the water particles flash evaporate when they come into contact with any warm surface such as the skin of an animal or person. The result is a cool animal environment with little wetting of the animal's hair-coat and virtually no wetting of the animal's bedding.

Unlike prior disclosed systems in which the fans in a circuit are limited to synchronous oscillation, the present system allows either synchronous oscillation or it allows each fan within a circuit to be programmed so that each individual fan oscillates over different zones for any desired time period. The oscillation of each fan can be directed to a particular degree range according to different specified times of the day, according to observed environmental conditions, or according to specific locations where the animals are located. This ability to direct effective cooling according to the location of the animals and the real time environmental conditions increases animal comfort and health. Programming can be changed at any time to meet the individual preferences of the animal herds person.

Fan oscillation and water output can be varied according to a pre-programmed schedule or through real time monitoring of current environmental conditions. Current temperature, humidity and wind conditions may be monitored for different zones within a facility and the fan oscillation modified as required as disclosed herein. The water output may be controlled as required by a variable-frequency-drive on a high-pressure water pump. Water output may also be controlled by switching nozzle sizes and/or increasing the number of nozzles instead of or in addition to changing pump pressure output. In conjunction with programmable oscillation, programmable water output allows the herds person to fine tune the animal's environment for maximum economic gain and animal comfort.

SUMMARY OF THE INVENTION

The present invention is directed to a livestock cooling system which creates an environment which protects the health and productivity of the animals. The livestock cooling system may be installed to a structure having at least one fan support member. A fan, which creates an air stream, is rotatably coupled to the fan support member. An oscillation motor is operably connected to the fan for rotating the fan through a plurality of rotational positions, wherein the rotation of the fan between any two rotational positions describes an arc length. A position indication device senses either the rotational position of the fan or the rotational position of a rotatable shaft connected to the fan. The position indication device provides an output signal in response to the rotational position of the fan or the rotatable shaft. The output signal is provided to a control means which is electrically connected to the oscillation motor. Monitoring means which are connected to the control means, provide real time advice to the control means of the a desired arc length through which the fan and/or rotatable shaft should be traversing. Upon receiving the advice from the monitoring means, the control means causes the oscillation motor to oscillate the fan through the arc length which has been specified by the monitoring means. The fan may be further equipped with means for injecting water droplets into the air stream of the fan to create a fog or mist which further enhances the cooling effect of the cooling system.

A plurality of fans, each having its own oscillation motor, position indication device, and control means, may all be connected to the same monitoring means, thereby allowing each fan to oscillate through a different arc length as required for the particular facility. As with the individual fans, each fan in the multiple-fan system may be equipped with means for injecting water droplets into the air stream of each fan, where a pump is used to deliver water to each fan. The flow rate of water droplets may be adjusted by adjustment means, such as a variable frequency drive connected to the pump.

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying

drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a fan station for one embodiment of the disclosed livestock cooling system.

Fig. 2 is a second perspective view of a fan station for the embodiment of Fig. 1.

Fig. 3 is a cross-sectional view of the fan of Fig. 2 taken along line 3-3.

Fig. 4 shows a first configuration for coupling the oscillation motor to the fan.

Fig. 5 shows a second configuration for coupling the oscillation motor to the fan.

Fig. 6 shows a plurality of fan stations may be connected to a single processor.

DETAILED DESCRIPTION OF THE EMBODIMENTS

It is to be understood that for purposes of the present disclosure, the term "livestock" used herein includes horses, cattle, swine and poultry. Referring now specifically to the drawings, Fig. 1 shows one embodiment of a fan station 8 for the disclosed livestock cooling system. This embodiment of a fan station 8 comprises a fan support member 10, to which a fan 12 is rotatably coupled. The fan 12 creates an air stream 14. An oscillation motor 16 is operably connected to fan 12.

Figure 1 shows one means of coupling the oscillation motor 16 to the fan 12. In this embodiment, the fan 12 has a fan housing 18. While any number of materials may be used for the fan housing 18, it is to be appreciated that light-weight materials such as plastics, composites or thin-walled sheet metal are desirable to minimize the weight. An attachment bracket 20 is attached to the fan housing 18. Connected to the attachment bracket is a yoke assembly 22 which comprises a shaft sleeve 24. Shaft sleeve 24 is attached to rotatable shaft 26 with locking means such that shaft sleeve 24 and the fan components attached thereto rotate as rotatable shaft 26 rotates. Rotatable shaft 26 is operably connected to oscillation motor 16. As shown in Figure 1 and Figure 2, rotatable shaft 26 may penetrate through the bottom side 28 of fan support member 10, passing through bearing 30, which may be a journal or roller type bearing. Rotatable shaft 26 extends through the top side 32 of the fan support member 10, where it is engaged by oscillation motor 16, which may be attached to the top side 32 of the fan support member 10. Oscillation motor 16 may be a SUMITOMO HYPONIC sub-fractional gearmotor of

the hollow shaft type, or equivalent, which has a right angle hollow shaft for engaging rotatable shaft 26.

Oscillation motor 16 is started and stopped by control means 34. As shown schematically in Figure 4, control means 34 comprises a control box 38 containing a central processing unit 40 ("CPU"), a power supply 42, and current control means 44 for starting, stopping, and reversing oscillation motor 16, such as relays and/or silicon-controlled rectifiers ("SCRs") or thyristors. Such devices allow the oscillation motor 16 to start rotating the rotatable shaft 26 from a first rotational position and to stop rotating the rotatable shaft at a second rotational position, where the rotation of the rotatable shaft from the first rotational position to the second rotational position describes an arc length. Upon the rotatable shaft 26 rotating to the second rotational position, control means 34 stops the oscillation motor 16. Electrical current to the oscillation motor is reversed by the current control means 44 of the control means 34, causing the oscillation motor 16 to rotate in the opposite direction, returning the rotatable shaft 26 back to the first rotational position, where the control means 34 once again stops oscillation motor 16, and another cycle of oscillation is begun. Control means 34 may be further equipped with soft-start and soft-deceleration components to prevent damage to oscillation motor 16 and other system components during the oscillation cycle.

Control means 34 receives a signal produced by position indication device 36, which senses the rotational position of the rotatable shaft 26 and provides an output signal in response to the observed rotational position of the rotatable shaft to the CPU 40 of the control means 34. Because the rotatable shaft 26 is directly coupled to the fan 12, the position indication device 36 provides the rotational position of the fan 12 itself to the control means 34. Suitable position indication devices 34 include rotary displacement sensors, such as the RVIT-Z series manufactured by SCHAEVITZ. Alternatively, an optical encoder may be used as the position indication device 36. Suitable encoders are manufactured by DYNAPAR.

As shown schematically in Figure 6, the CPU 40 of each control means 34 in a circuit of fan stations 8 receives real time values from monitoring means 46 regarding the desired arc length for each fan, which is defined by two rotational positions of the rotatable shaft 26 for a given fan station 8. Monitoring means 46 may be a programmable logic controller ("PLC").

Because of its programmability, the monitoring means 46 may vary the desired arc length (i.e., a starting rotational position and a stopping rotational position) for a particular fan 12 in the system according to any number of input values, including time of day, temperature as inputted from a temperature sensing device, humidity as inputted from a humidity sensing device, wind speed and direction as inputted from a wind sensing device, or light intensity as inputted from a lumen measuring device or ultra violet light meter. It is to be appreciated that different zones within a facility might have different environmental conditions for a particular time of day. Environmental sensors detecting each of the above conditions (i.e., temperature, humidity, wind velocity, etc.) may be located within each different zone, with input values reported to the monitoring means 46. The present invention allows the herds person to control the fan stations 8, including water volume and pressure, within each zone to achieve the optimal oscillation and water injection for that zone

Monitoring means 46 will typically communicate with the CPU 40 of the control means 34 via serial communication interfaces 48, such as RS-232 or, more typically because of the distance between the PLC and the CPU and the benefit of connecting multiple CPUs to a single PLC, a RS-422/485 interface, which may be used in conjunction with a RS-232 to RS-422/485 or other appropriate converter. The RS-422/RS485 protocol typically allows the monitoring means 46 to send and receive data from the CPUs 40 of thirty-two different fan stations 8 from distances of several thousand feet, although both the number of stations may be expanded by adding an additional interface, or by new technology. It is to be appreciated that other communication protocols might also be used between the monitoring means 46 and the control means 34, such as 0-90 VDC or radio communications.

The CPU 40 contained within control means 34, compares the start and stop values received from the monitoring means 38 to the values reported to the CPU from the position indication device 36. The CPU provides output to the oscillation motor 16 via the current control means 44, which may be silicon-controlled rectifiers or relays, so that the oscillation motor starts at the desired rotational position and rotates the rotatable shaft 26 (and the attached fan 12) to the desired stop point, at which point current to the motor is reversed through the current control means 44, causing the oscillation motor 16 to reverse direction, rotating rotatable shaft 26 (and

the attached fan 12) back to the original starting point. This cycle is continued until the monitoring means 46 provides new start and stop values to the control means 34, or the monitoring means advises the control means that oscillation should stop.

As shown in Figure 1 and Figure 3, each fan 12 comprises a blade 50 enclosed within fan housing 18, a motor 52 attached within the fan housing for rotating the blade, and a grill 54 may be attached to the front of the housing. As shown in Figure 1, a mist ring 56 may be attached to the grill 54, and nozzles 60 attached to the mist ring. A high pressure water line 62 is connected to the mist ring 56 for providing high pressure water to the nozzles 60. Power cable 64 provides electrical power to the motor 52. Fan 12 creates an air stream 14 into which water droplets may be injected from the nozzles 60 mounted within the mist ring 56. Stainless steel or other corrosion resistant materials with acceptable pressures ratings are acceptable materials for construction of the mist ring 56. Nozzles 60 may be screwed into female connections welded to mist ring 56 or otherwise attached. Water is delivered into high pressure water line 62 by a pump which is controlled by monitoring means 46. The pump flow rate, and thus outlet pressure, may be controlled by various pressure control means, such as a variable frequency drive located in either a local panel or within monitoring means 46.

Motor 52 may be disposed at the approximate center of the fan housing 18 to achieve optimal balance. Because motor 52 is disposed within air stream 14 (i.e., the blade 50 of the fan 12 is located behind the motor), the motor is cooled by the fan blade 50

When water droplets are injected into the air stream 14 of each fan 12, there is the possibility of creating a drench, a mist, or a fog, depending upon, among other factors, including environmental conditions, the volume of injected water, the injection pressure, and the droplet size. A drench showers the animal, wetting the animal to its skin, but is not normally a suitable cooling method when the animal is in its bedding area or is being milked. With a mist, the water droplets injected into the air stream 14 are smaller than with a drench, but the air becomes saturated with continued water injection, resulting in the animals and bedding becoming wet. A mist creates an undesirable water layer on the animal which acts as an insulator and retains heat. With fog, water is emitted through very small diameter nozzles 60 at a sufficiently high pressure so as to result in extremely small water particles. These water particles will flash evaporate when

the particles come into contact with any warm surface such as the skin of an animal or person, resulting in a cool animal environment with little wetting of the animal's hair-coat and virtually no wetting of the animal's bedding.

Figure 4 and Figure 5 show different configurations of connecting an oscillation motor to a rotatable shaft. Figure 4 generally depicts a first configuration where the oscillation motor 16 is connected to a rotatable shaft 26 as described above. Rotatable shaft 26 has a first end 66 which extends below the bottom side 28 of fan support member 10. Rotatable shaft 26 may have a second end 68 which passes through the top side 32 of fan support member 10 and second end 68, or an extension thereof, is engaged by the hollow shaft 70 of the oscillation motor 16. Second end 68, or an extension thereof, extends through the hollow shaft 70, and is connected to position indication device 36. It is to be appreciated that while Figure 4 schematically shows control means 34 to be located above oscillation motor 16, control means 34 may be remotely located in control box 38 a short distance away from the oscillation motor 16 and the position indication device 36.

Figure 5 shows a second configuration for connecting an oscillation motor 16' to a rotatable shaft 26'. In this embodiment, first end 66 of the rotatable shaft (not shown in Figure 5) is the same as described above. However, fan support member 10' has been modified for attachment of gear housing 72. First gear 74 is disposed on second end 68' of rotatable shaft 26'. Second end 68' is provided lateral and vertical support by bottom bearing 76, which must be capable of supporting the weight of fan 12, including dynamic loading induced by oscillation of the fan. Second end 68', or an extension thereof, extends through top bearing 78, and connected to position indication device 36. A drive gear 80 is disposed adjacent to first gear 74 and engages the first gear. Drive gear 80 is connected to gearbox 82. First gear 74 and drive gear 80 may be enclosed within gear housing 72. Oscillation motor 16' may be coupled to gearbox 82. Drive gear 80 is supported by needle bearing 84. An acceptable oscillation motor 16' is manufactured by LINIX MOTOR COMPANY.

Whether the first configuration or second configuration is utilized, it has been found desirable to maintain a relatively slow oscillation speed, such as 2 to 6 RPM. The slower oscillation provides efficient cooling of livestock and also reduces equipment wear and

maintenance which may be required for faster oscillation speeds. The specific components of the system, including the gear ratios of the oscillation motor 16 and gear box 82, may be specified by those skilled in the art to achieve the desired oscillation speed.

While the above is a description of various embodiments of the present invention, further modifications may be employed without departing from the spirit and scope of the present invention. For example, the size, shape, position and/or material of the various components may be changed as desired. Thus the scope of the invention should not be limited by the specific structures disclosed. Instead the true scope of the invention should be determined by the following claims.